Fine-grained Long-range Workload Prediction

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Inception

Embedded Learning™

- Learning is key
- Learning requires data
- Real data are expensive
- Simulated data are expensive

Synthesize to Excel

1. Synthesize data
2. Explore wildly your wild ideas
3. Prototype the promising ones
4. Fine-tune in a real environment

Synthesize to Excel

- “How accurate…?”
- “How to validate…?”
- “How to guarantee…?”

Real Data

Google's Cluster Data

- 1 month, May 2011
- 13,000 machines
- 700,000 jobs
- 1,000 users

Google's Cluster Data

- Machine events
- Machine attributes
- **Job events**
- Task events
- Task constraints
- **Task resource usage**

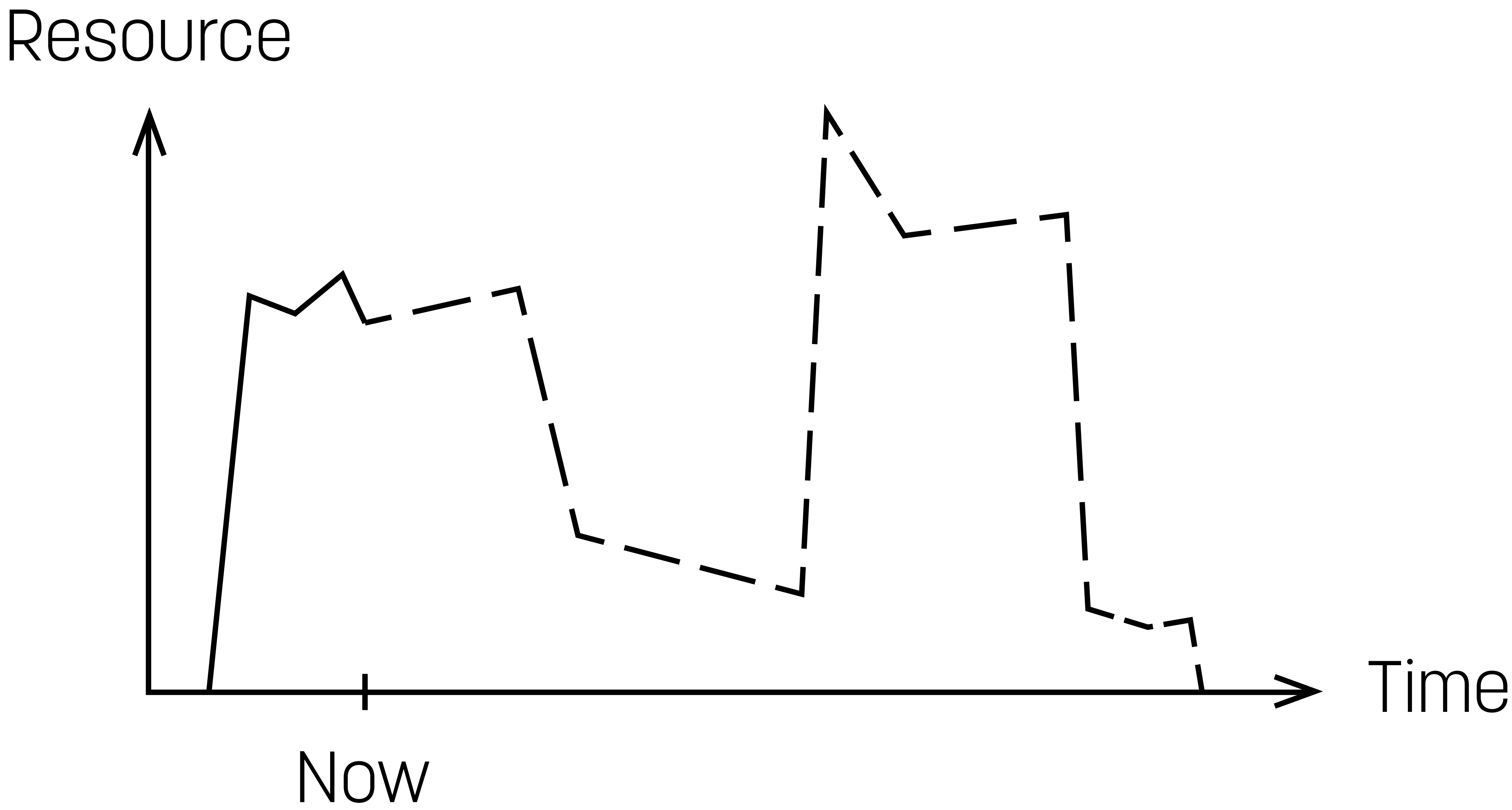
Question

- Can we predict the (inter)arrival times of individual jobs multiple steps ahead?
- To be answered: December 15
- Spoiler: sǝ⅄

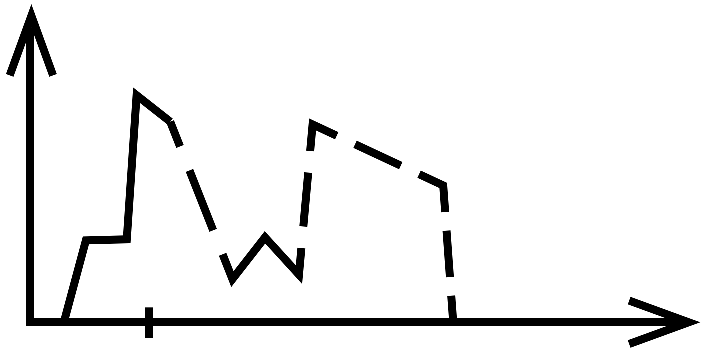
Question

- Can we predict the transient resource usage of individual tasks all the way until their completion?

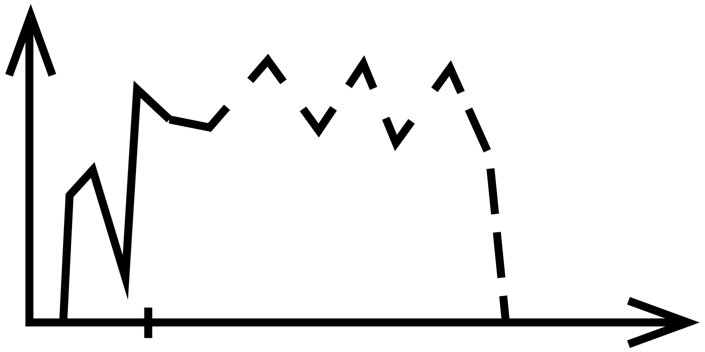
Example



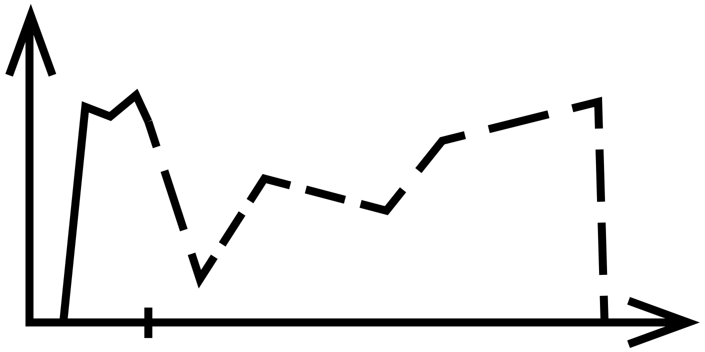
Example



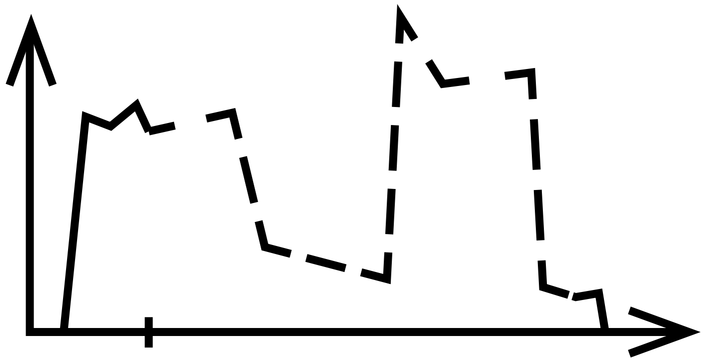
Machine 1



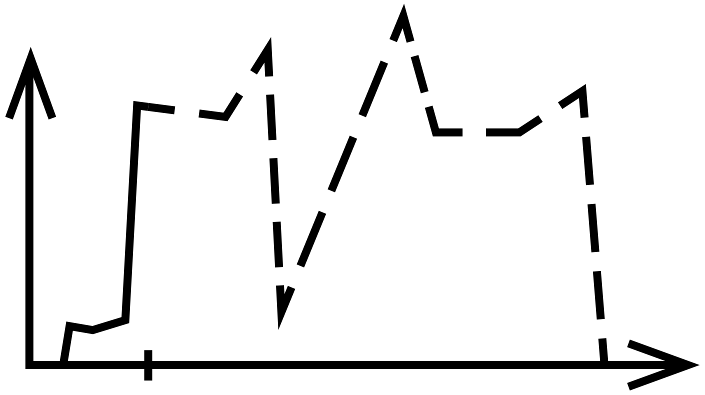
Machine 2



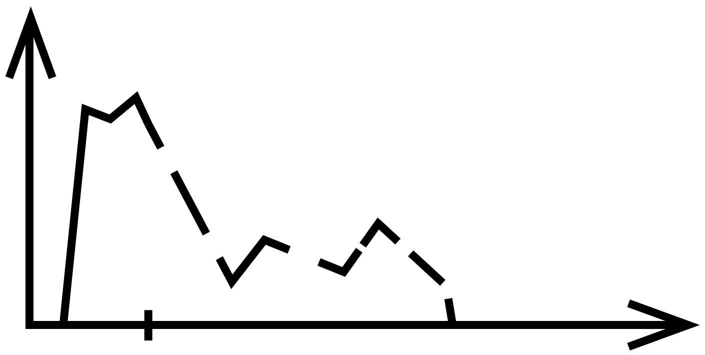
Machine 3



Machine 4



Machine 5



Machine 6

Google’s Resource Usage

- CPU, memory, and disk I/O
- Mean and max over 5-minute intervals
- 300 measurements per interval

Google's Resource Usage

- 200 GB
- 1,300,000,000 records
- 10 minutes for "SELECT COUNT(*) FROM table"

Google’s Resource Usage

- Slice and dice
- Organize in a catalog of traces
- Mean CPU (over 5-minute intervals)

Prediction

Google’s Resource Usage

- Sequential data
- Non-trivial structure
- Long-range dependence

Machine Learning

- No hand-crafted algorithms
- Embrace and learn from experience

Neural Networks

- The state-of-the-art in you-name-it

ESWEEK'16

- **Neural Network** Transformation and Co-design under Neuromorphic Hardware Constraints

ESWEEK'16

- Cambricon: An Instruction Set Architecture for **Neural Networks**

ESWEEK’16

- RRAM Based **[Deep] Learning** Acceleration

ESWEEK'16

- Hybrid Network-on-Chip Architectures for Accelerating **Deep Learning** Kernels on Heterogeneous Manycore Platforms

ESWEEK'16

- CaffePresso: An Optimized Library for **Deep Learning** on Embedded Accelerator-based platforms

ESWEEK'16

- Going Deeper than **Deep Learning** for Massive Data Analytics under Physical Constraints

ESWEEK'16

- Zero and Data Reuse-aware Fast Convolution for **Deep Neural Networks** on GPU

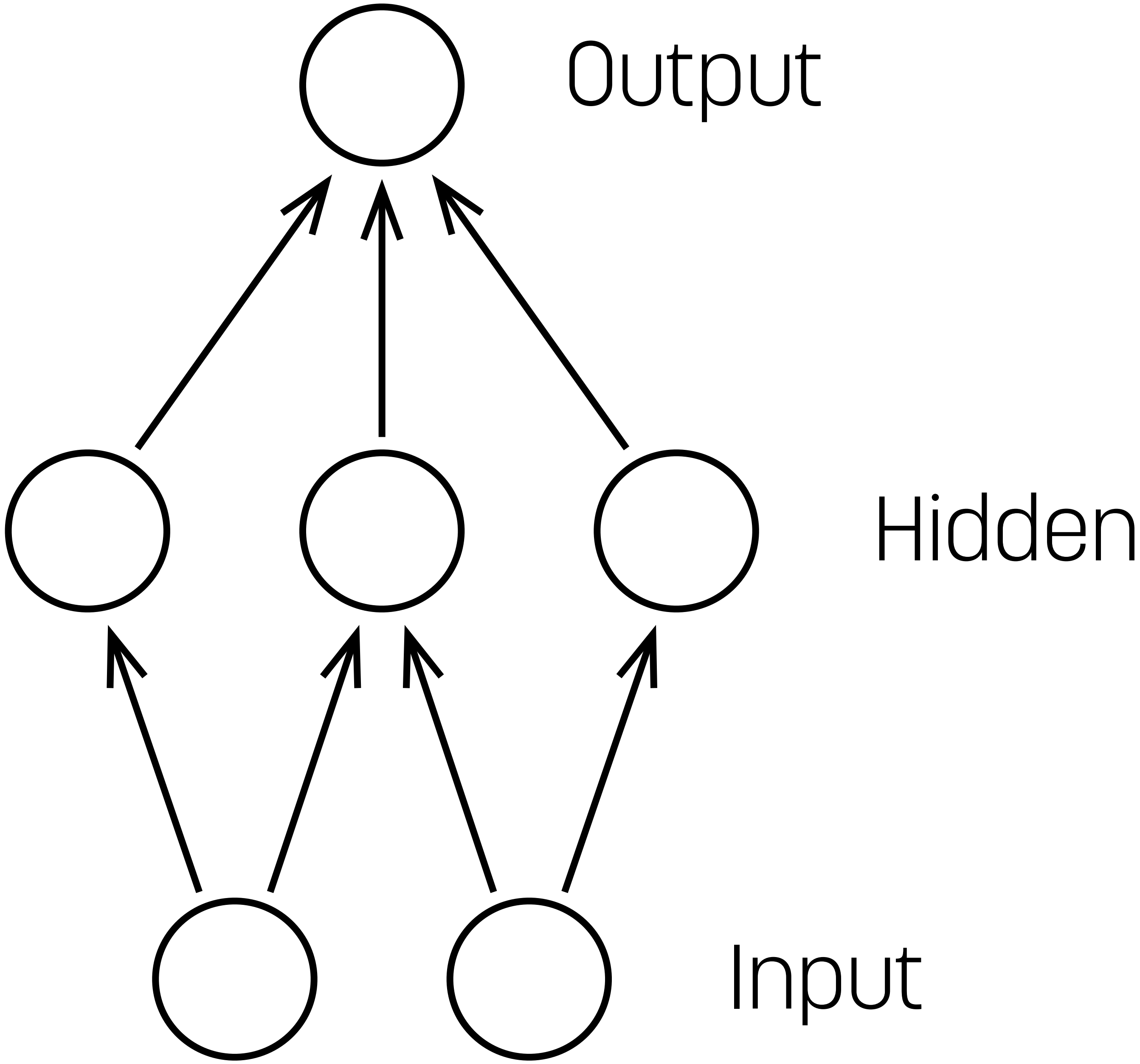
ESWEEK'16

- Runtime Configurable **Deep Neural Networks** for Energy-Accuracy Trade-off

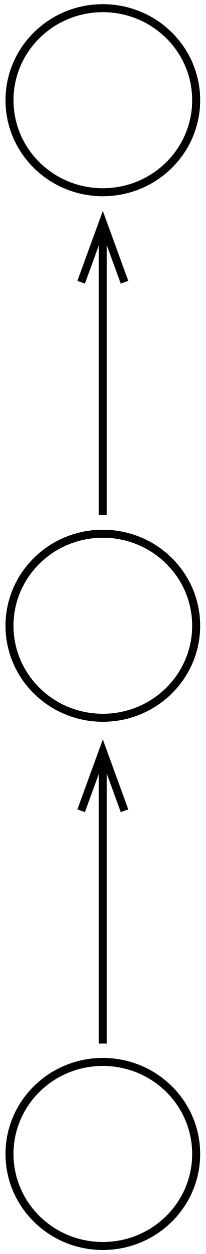
Neural Networks

- Hot

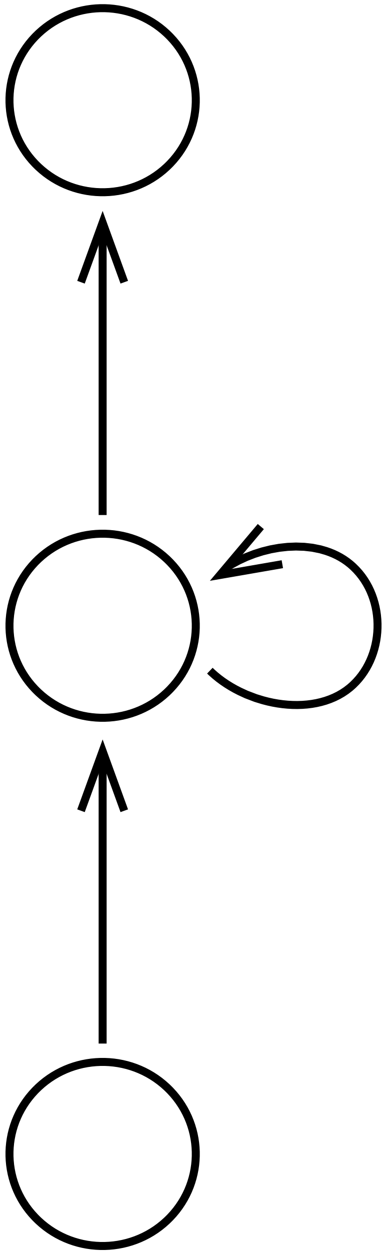
Feedforward Neural Networks



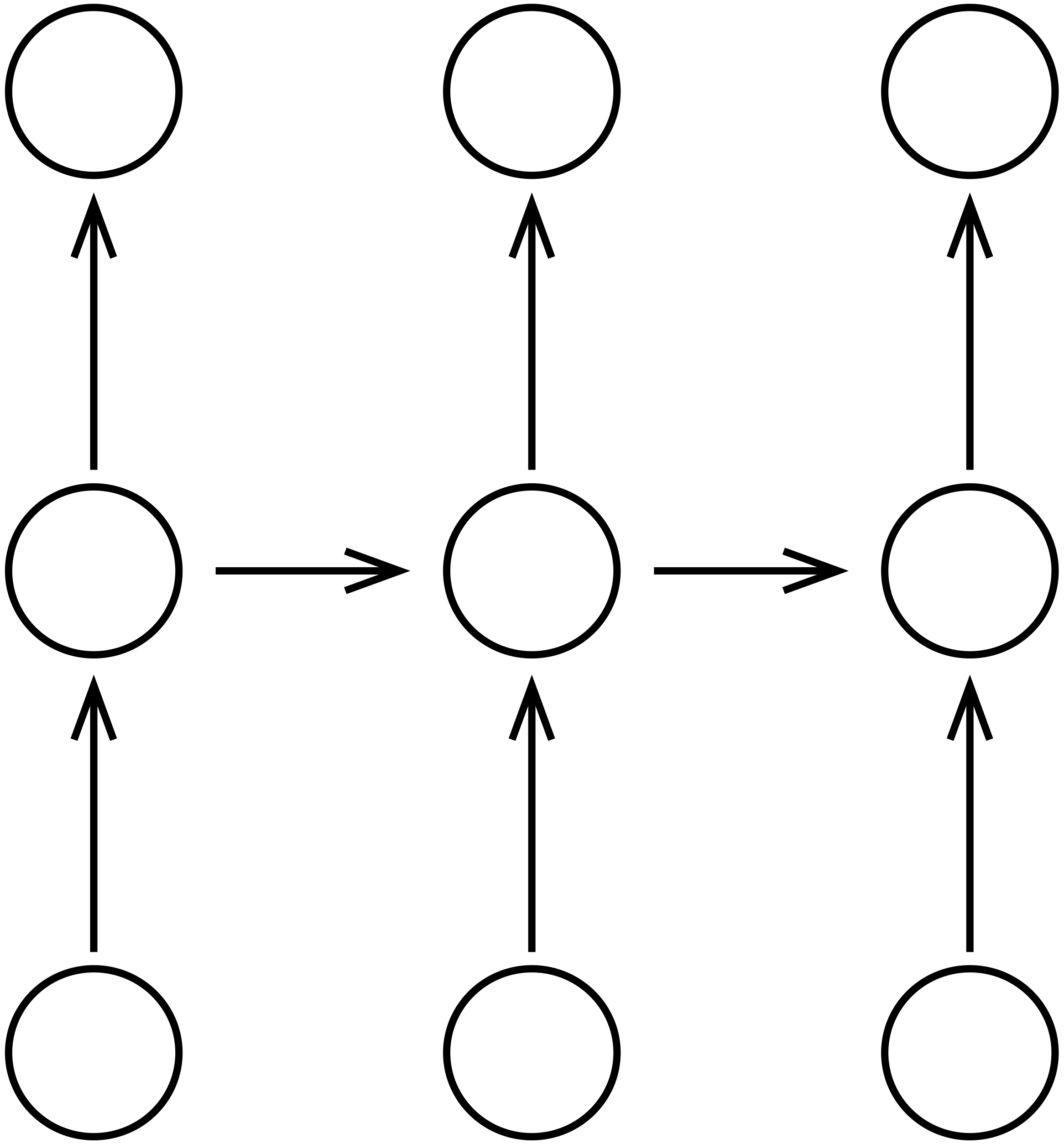
Feedforward Neural Networks



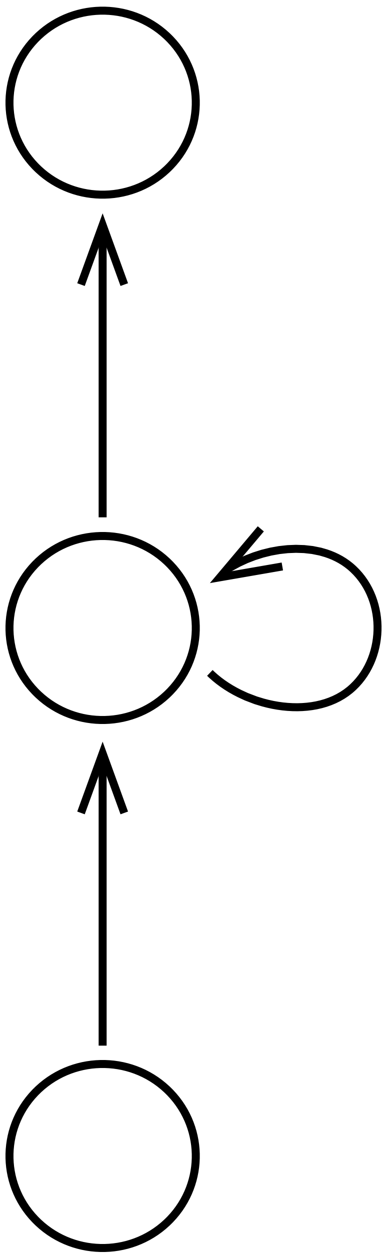
Recurrent Neural Networks



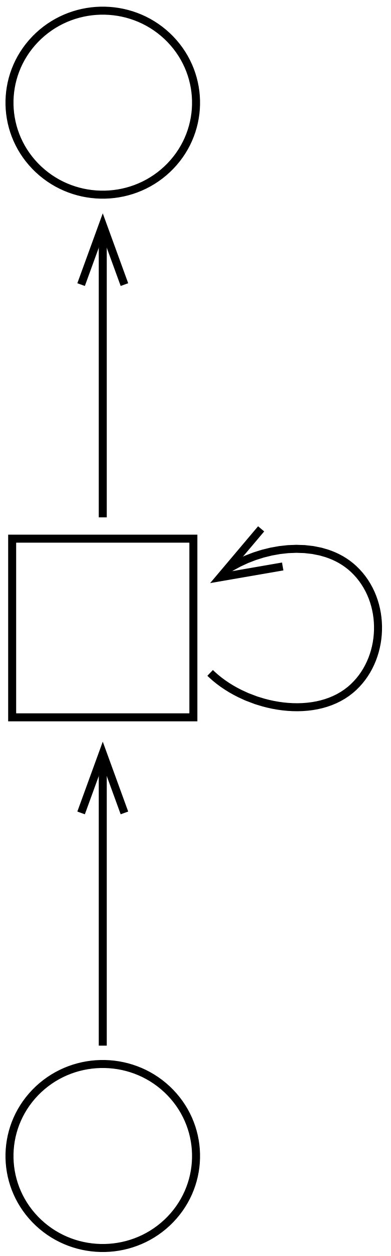
Recurrent Neural Networks



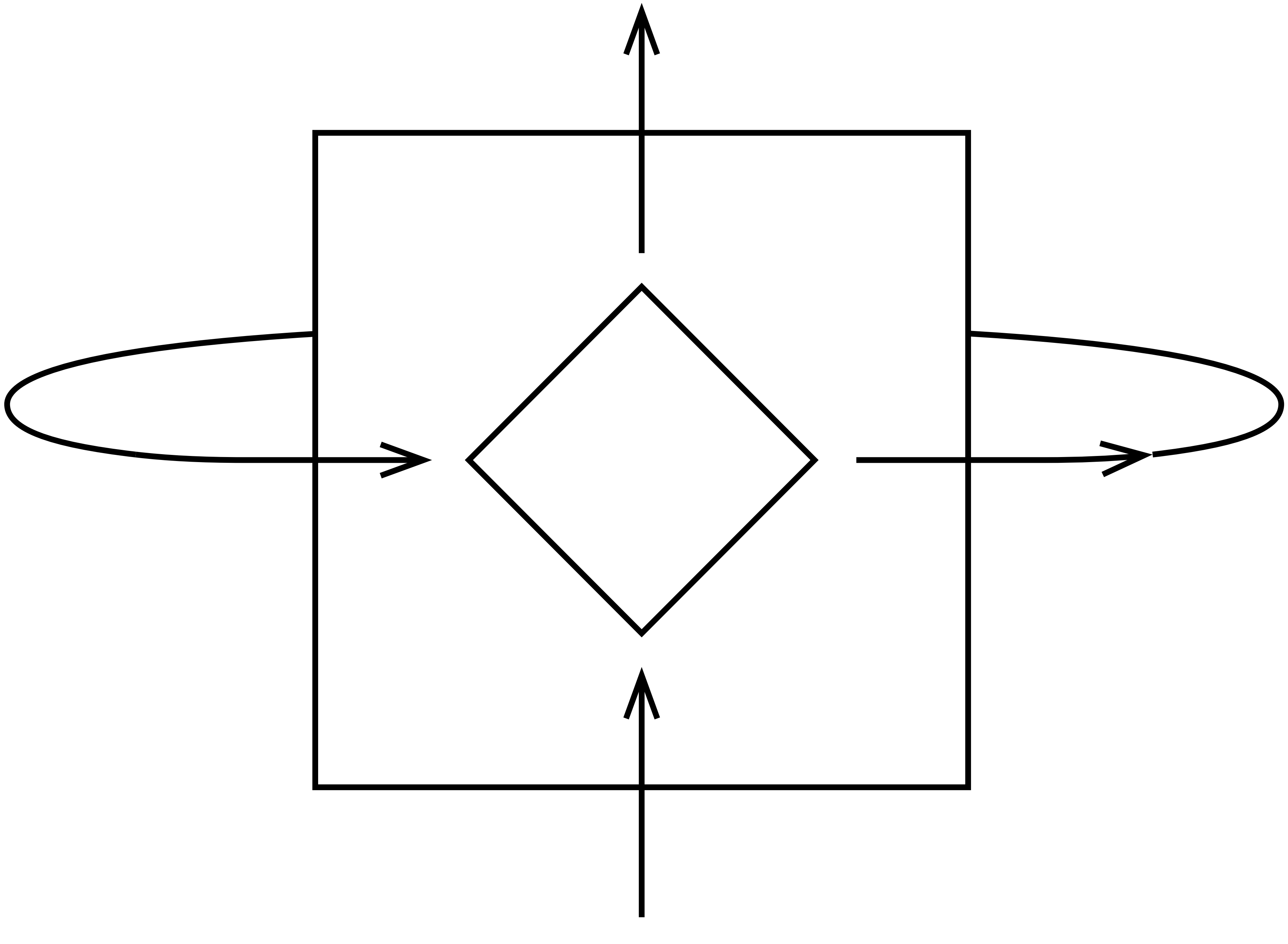
Recurrent Neural Networks



Memory Modeling



Memory Cell



Stay tuned for more…

Thank you!
Questions?